

ROAD SLOPE MANAGEMENT IN MALAYSIA

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Abstract

Most of the landslides in Malaysia occurred within man-made slopes. Recently a landslide in Bukit Antarabangsa, not far from the capital, Kuala Lumpur killed 5 people and caused 16 injuries. The landslide also cut off the main municipal trunk road, the only access for about 5000 people in the surrounding areas. This is one of the many landslides that cut off roads and killed road users or the residents nearby. After a series of landslides since the year 1993 when the Highland Towers landslide incident occurred, a Slope Engineering Branch (CKC - Cawangan Kejuruteraan Cerun) was established in February 2004 within the Public Works Department of Malaysia. The goal of the establishment of CKC is to ensure safer slopes for the country using the state-of-the-art technology in slope engineering. Although CKC was established to oversee all slopes in the country, but the major task is to ensure all the slopes under the authority of the Public Works Department, Malaysia are properly managed. Some of the strategies and actions include: formulating a national policy on slopes; cataloguing of slopes along the roads; formulate new standards and guidelines on maintenance for slopes; produce design guidelines on slopes; promote public awareness on slope hazards; implement preventive maintenance on problematic slopes; develop staff competencies in slope engineering; develop a system on information management and dissemination; and others. This paper describes some of the road slopes management undertaken in Malaysia and what are the problems faced.

1. INTRODUCTION

Landslide came into prominence in Malaysia in 1993 when an apartment block near Kuala Lumpur collapsed due to a landslide killing 48 people. Landslide occurrences have been increasing recently especially along the roads due to roads constructed that traversed through hilly regions in Malaysia. In 2004, a dedicated Slope Engineering Branch (CKC)

was established within the Public Works Department of Malaysia (Jabatan Kerja Raya – JKR) after a rock slope failure at Bukit Lanjan caused a major toll highway leading to the capital, Kuala Lumpur was cut off for more than 6 months (Fig. 1).



Figure 1 Bukit Lanjan landslide that closed a part of the toll expressway near Kuala Lumpur

Since 1973 landslides have killed nearly 600 people (Public Works Department, 2008). Data obtained by CKC from reported landslides in 2007 and 2008 showed the most affected facility due to landslides in Malaysia was roads and then followed by building, houses and others (Slope Engineering Branch, 2009). Fig. 2 shows the facilities affected due to landslides in 2007 and 2008.

15 federal roads have been identified as having many slopes that may have many high hazard slopes. Federal roads are roads that are maintained by the Malaysian Federal Government; usually they are trunk roads that connect major towns and cities within

Malaysia. Other roads include state, municipal and village roads which are constructed and maintained by various authorities.

The recent landslide in Bukit Antrabangsa near Kuala Lumpur again brought the issue on landslide into the fore. In this incident, apart from 5 lives were lost and 14 houses were destroyed, the landslide also cut off the main local authority trunk road - the only access for about 5000 people in the surrounding areas.

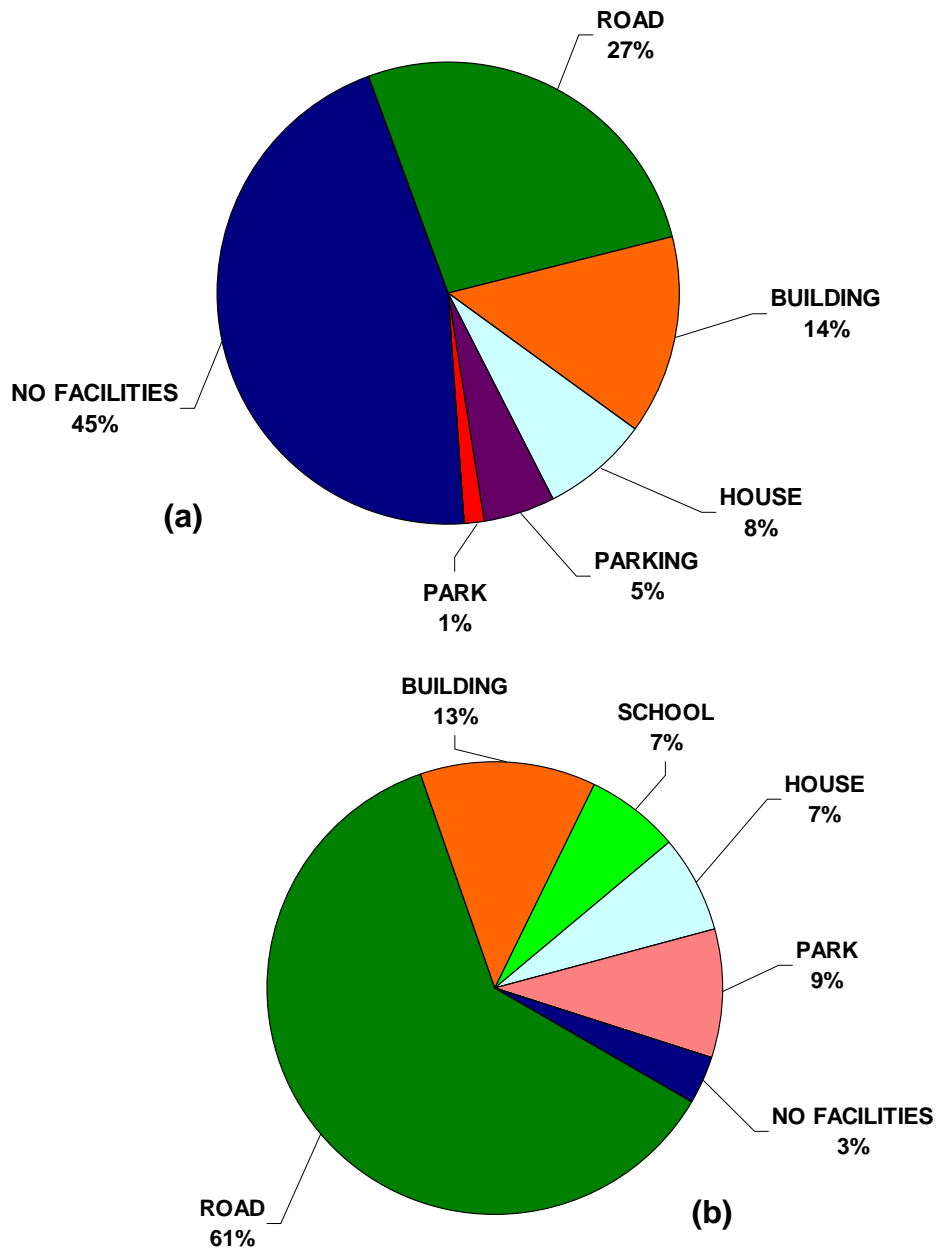


Figure 2 Facilities affected by landslide in the year: (a) 2008; and (b) 2007

One of the things that have become the main priority of CKC since its inception is gathering of data on the conditions of slopes and especially on producing of hazard maps for road slopes. JKR has also completed a comprehensive National Slope Master Plan study in 2008 with the goal of reducing losses due to landslides. Other schemes to reduce landslides and landslide losses include preventive measures and periodic maintenance.

2. DATA COLLECTION AND HAZARD MAPPING

One of the difficulties in slope management in Malaysia is the lack of information on slopes in Malaysia. One of the most important aspects of slope management is obtaining database for slopes for the purpose of planning, budgeting, development decision making, slope hazard rating, the slope conditions, data sharing and dissemination, for all intent and purposes, data is essentially the most important thing for an effective slope management. Inadequate information may lead to wastage of funding, difficulty in justifying budget allocation, wrong type of treatment for the slope, difficulty in preparation yearly budget and even when money is spent on the slopes, the safety of most of these slopes may not be enhanced if information on the slope is inadequate.

That is the reason why JKR is spending time and money on gathering information and inventorizing the slopes especially along the critical roads. To date 19,000 slopes along the federal highways have been inventorized. Five of the 15 roads have had their slopes hazard rated. JKR has been trying to acquire funding to strengthen the very high hazard and risk slopes along these roads. Fig. 3 and 4 present the hazard and risk maps respectively along Tamparuli- Sandakan road, one of the critical roads listed amongst the 15 roads mentioned above.

The hazard rating of the slopes along the roads is based on the study been done along the Tamparuli-Sandakan road. The hazard rating or score is based on a ranking system known as 'Slope Management And Risk Tracking or SMART.' The SMART system has been applied elsewhere within Malaysia and is found to be valid for linear application i.e. for road slopes.

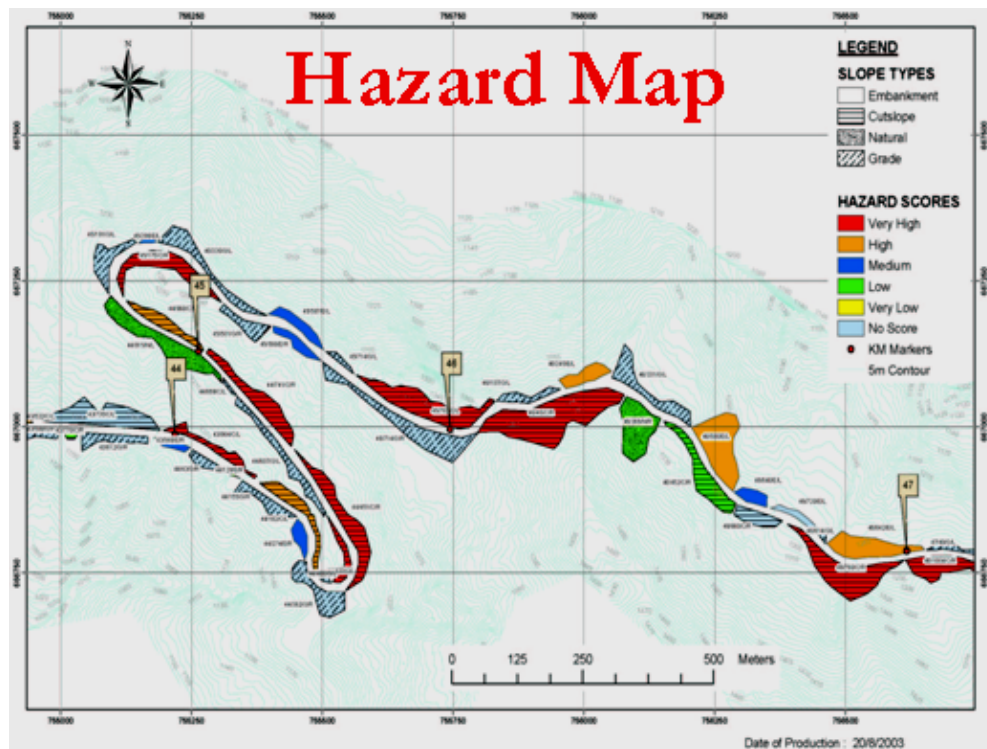


Figure 3 Hazard map along the Sandakan-Tamparuli road in Sabah, Malaysia

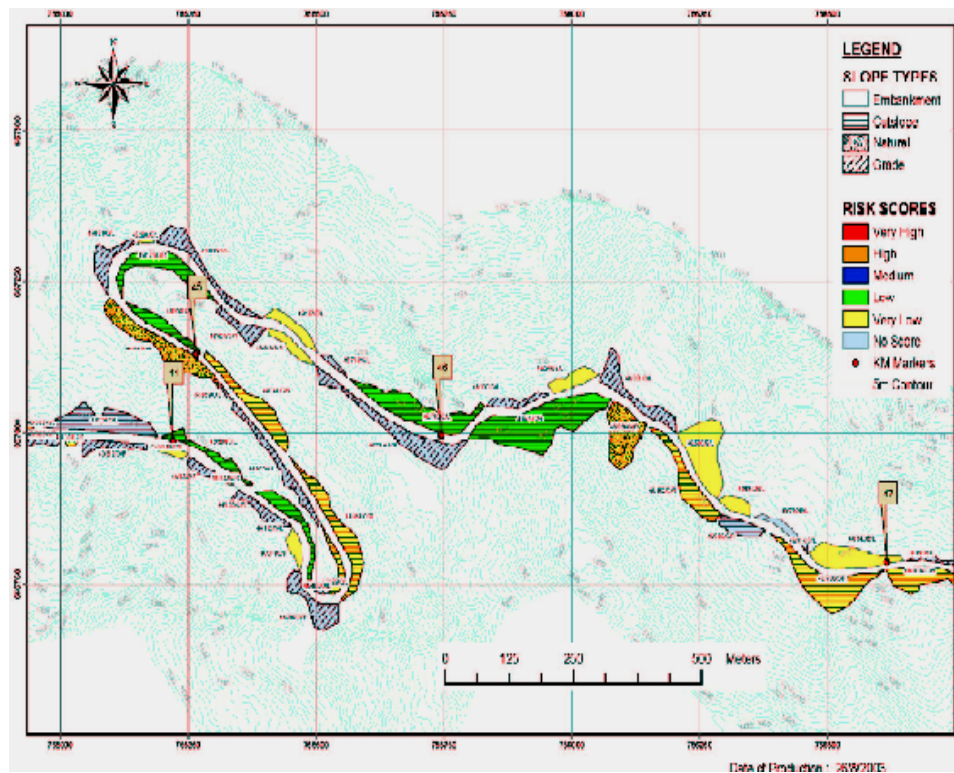


Figure 4 Risk map along the Sandakan-Tamparuli road in Sabah, Malaysia

3. SLOPE INSPECTION PROGRAM

Malaysian weather is influenced by two monsoon seasons, the Northeast monsoon blowing from the South China Sea and the Southwest monsoon blowing from the Indian Ocean. The Northeast monsoon usually begins in November until March and the Southwest monsoon from May to September. The monsoon seasons, especially the Northeast monsoon brings heavy rain to Malaysia. Sabah, Sarawak and the east of Peninsular Malaysia are generally affected by the Northeast monsoon, while the Southwest monsoon affects the west side of Peninsular Malaysia. Slope inspection program is carried out in preparation of these monsoon seasons with the help of the district engineer's staff.

The emphasis during the slope inspection is ensuring the drainage system is well maintained, i.e. free of debris, any damages have to be reported and repaired. Another aspect of slope inspection is to detect signs that may indicate or cause instability such as tension cracks and seepage within the slopes. This program has just been initiated, guidelines for maintenance has been introduced. At the outset the process seems to be quite simple, yet to ensure the effectiveness of the program requires a lot of groundwork such as training for the inspectors – usually technicians and engineer's assistants, proper equipments, and of course enough personnel to carry out the inspections. Other impediment to the slope inspection program is inadequate facilities for inspection purposes. Usually cut slopes in Malaysia are constructed at more than 35° to the vertical, some rock slopes are constructed at more than 75° which means that a special ladder or stairs have to be provided for scaling the slopes, however, frequently the facilities were generally ignored during the design. On top of this problem, the slopes are generally well vegetated. JKR is trying to remedy the situation by constructing facilities to facilitate inspection of the slopes.

Previously, the cut slope height constructed was not limited, so our highest cut slope, which could probably be the highest cut slope in the world is approximately 240m. Many slopes are more than 40m high which means only the very fit personnel would be able to scale the slopes. Coupled with the inadequate facilities as mentioned above, the task of proper inspection is next to impossible. Apart from manual inspection, JKR are looking at ways to carry out remote inspection. One of the ways is to inspect using

unmanned model helicopter or plane with viewing device attached; however, this is still under going trials and experiments.

Once the inspection process is done the next step would be to perform proper maintenance and repair. Apart from physical impediments mentioned above that makes maintenance and repair difficult and costly, the funding provided is inadequate. For routine maintenance and minor repairs of road slopes, JKR is provided with approximately USD 14 million annually.

4. GUIDELINES

Manuals and guidelines will facilitate routine works and procedure that need to be done quickly and efficiently. Several guidelines have been produced to help engineers, especially those in JKR to carry out their works. Guidelines were sometimes adopted with some modification from other established organizations that have already come up with a proper procedure.

Some of the guidelines that have been produced are slope design and maintenance guidelines. In the slope design guidelines, some cut slope and embankment dimensions are clearly spelled out, for example the maximum number of benches are now limited to 6 and the height between each bench shall not exceed 6m. The minimum bench width of the slope is also specified. The parameters of the soil/rock that have to be considered in the slope design are also specified.

The slope maintenance guidelines are adopted with some modification from Hong Kong maintenance guidelines. In the guidelines, inspection program for slopes is presented including the personnel and the frequency of inspection. The guidelines also include what need to be maintained and ways of maintaining slopes. As in any other maintenance guidelines, special attention is paid to the conditions of the drains on the slopes. Any signs of instability have to be attended speedily before the conditions become worst. Well and poorly maintained slopes were shown by way of pictures and illustrations. The maintenance manual can be downloaded for free from JKR's website and the maintenance guidelines have been distributed to local councils for maintenance of

their slopes, which usually include slopes along the municipal roads and around residential areas.

5. PUBLIC AWARENESS AND EDUCATION PROGRAM

Another aspect of slope safety which is not related directly to slope engineering but of equally important issue is public awareness and education program to assist communities and the general public on slope safety. The program would in effect also assist the agencies involved in slope maintenance to get feedbacks from the public on possible signs of slope instability along the road in an area so that proper inspection and action can be made by the relevant agencies.

Some of the programs that have been started include seminars and workshops for communities that live in critical areas. Poster sessions for slope safety including maintenance have been held in shopping malls, similarly, brochures and articles for the general public on slope safety, maintenance and information have been given to the public. One of the initial target groups is educating the local authorities' personnel so that they are able to identify potential slope instability and at the same time educating the public within their domain. In Malaysia, maintenance of existing slopes is almost always neglected (2009, Mohamad and Abdullah); therefore, special emphasis on the importance of maintenance for government and private slopes is presented during the seminars and public awareness sessions. Fig. 5 shows a poster session in progress in the shopping mall in one of the cities in Malaysia.

6. NATIONAL SLOPE MASTER PLAN

A comprehensive slope master plan has been produced in order to better manage slopes in Malaysia. The goal of the National Slope Master Plan (NSMP) is to reduce losses due to landslides (2006, Public Works Department, Malaysia). The NSMP is divided into 10 components that include: 1) Policy and Institutional Framework; 2) Hazard Mapping and Assessment; 3) Early Warning and Real-Time Monitoring System; 4) Loss Assessment; 5) Information Collection, Interpretation, Dissemination and Archiving; 6) Training; 7) Public Awareness and Education; 8) Loss Reduction Measures; 9) Emergency Preparedness, Response and Recovery; and 10) Research and Development.

In the NSMP, 77 implementation actions are recommended. Although the NSMP is meant for all slopes in Malaysia but since most of the slopes are along the roads the NSMP is most relevant to road slopes. Some examples of the recommended implementation actions that are applicable to road slopes are as follows:

1. Set up a network between stakeholders i.e. the relevant agencies.
2. Plan and carry out data collection.
3. Prepare hazard and risk maps.
4. Developed standard procedures for hazard and risk assessment and mapping etc.

The above are some of the examples of implementation actions that have direct impact on the management of slopes. Some of the implementation actions do not have direct bearing on slope management but are essential for a smooth and effective slope management process. The NSMP is to be implemented in 3 phases: Phase 1 is from 2009 – 2013; Phase 2 is from 2014 – 2018; and the final phase, Phase 3 is from 2019 – 2023. The total cost for the implementation of the action plans is estimated to be approximately USD 248 million over the period of 15 years. The implementation plans and the cost do not include any landslide mitigation measures because information on this matter is not yet available.

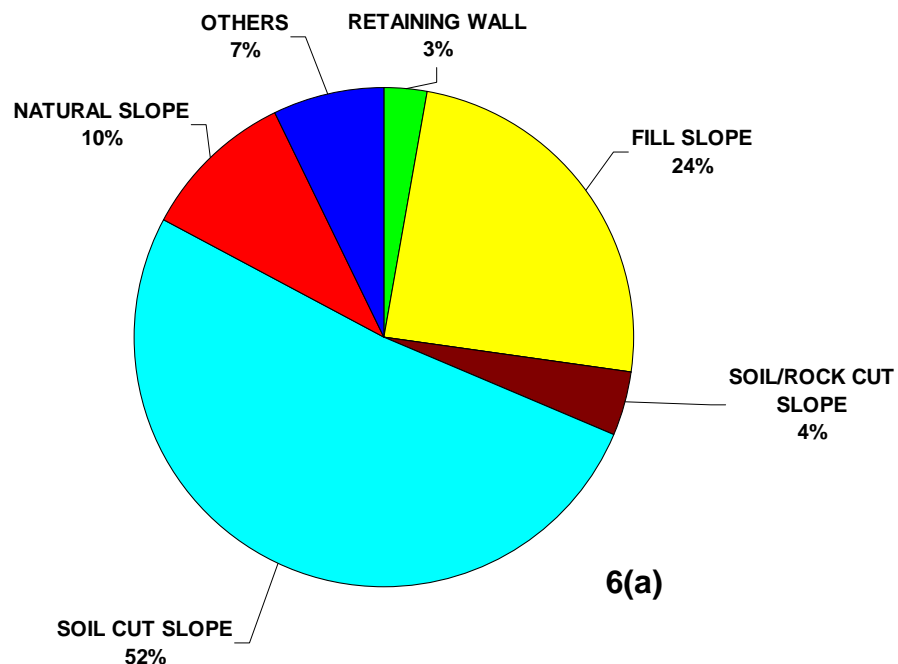
7. PREVENTIVE MEASURES

JKR spends approximately USD 4 million on upgrading of slopes. Most of the money is given to various JKR districts for minor works that are essential to prevent immediate

instability slope problems. The amount is very small considering there are already more than 19,000 slopes that have been inventorized and many high risk slopes have been identified. Major upgrading works on slopes required special funding which is difficult to obtain especially in the current economic situations.

Based on the data collected for 2008 and 2007, most of the slope failures occurred in soil cut slopes and then followed by fill slopes. Failures in soil/rock or rock slopes are not common because of these slopes are uncommon compared with soil slopes. Figs. 6(a) and 6(b) show the statistics of the materials within which slope failures occurred.

Most of the failures in soil cut slopes are may be due to poor design, maintenance or due to the relict geology which is still present in the soils even after the rocks have been completely weathered. In the case of embankments, many failures were initiated by leaking culverts or broken cascade drains which caused scouring and increase in pore water pressure in the embankments. The causes of these defects are either due to poor construction or design or both.



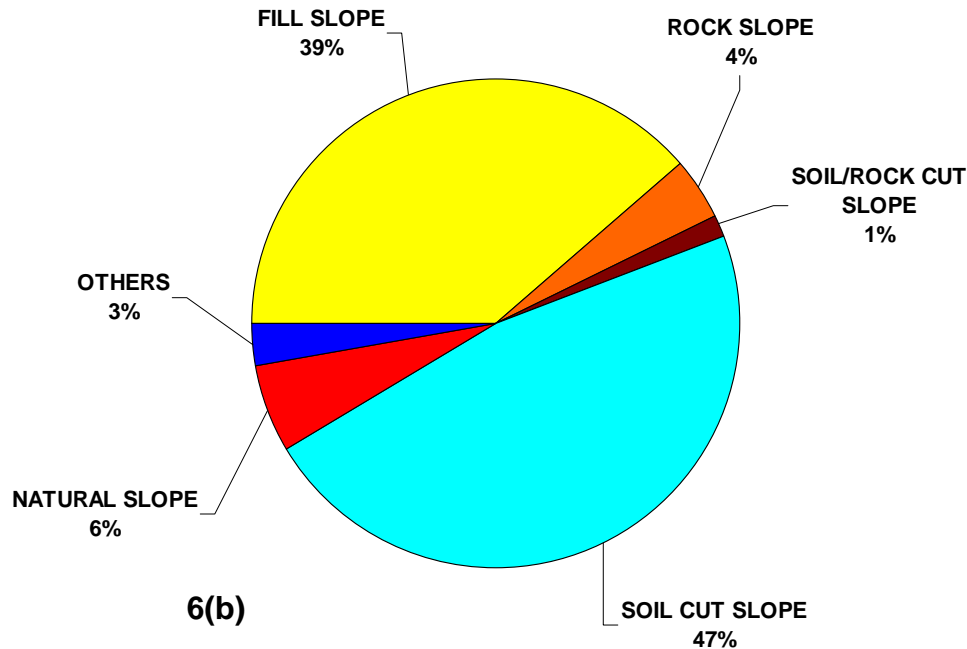


Figure 6 The statistics on materials where slope failure occurred: 6(a) in 2008; and 6(b) in 2007.

7. CHALLENGES IN SLOPE MANAGEMENT IN MALAYSIA

There are many challenges faced by JKR in managing the road slopes in Malaysia. It is only recently i.e. since the formation of the Slope Engineering Branch that the data on slopes are being collected and recorded. Modern technology such GPS and hand-held PDA makes data collection easier, but all the slopes still have to be visited and data collected at the required locations. The availability of GIS software helps simplify storage and presentation of data. The key challenges in slope management in Malaysia are as follows:

- One of the key challenges in slope management in Malaysia is the speed to gather the required information due to lengthy internal procedure and also the amount of fund required to carry out the works.
- The government usually is reluctant to spend enough money on preventive maintenance and slope treatments before failure but spent more than triple the amount for repair after failure on what could have been spent on preventing it.
- Ensuring planning, design, construction and maintenance of slopes are done to the required standards and specifications.

- Ensuring a continuous political and financial support of the Malaysian Government, cooperation and interaction between various relevant agencies and engaging the public.
- Training of personnel on various slope management subjects including data collection, design, maintenance and other issues related to slope.

From the above, it can be seen that Malaysia is just beginning to start on a proper slope management. The road to success in implementing a proper slope management is long and arduous. The success of implementing the NSMP depends on every stakeholders that include the public and most of all the political will of the Malaysian Government.

8. CONCLUSIONS

Systematic slope management in Malaysia is just in the initial phase. There are many things that need to be done especially on inventorizing and data collection of slopes for effective and efficient planning purposes. One of the major challenges for JKR is to convince the government to provide funding for mitigation measures instead of paying dearly for repairs.

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